CHAPTER 4
DATA COMMUNICATION

SHORT AND LONG QUESTIONS

Q.1 Define data communication.

Ans: Data Communication:

Data communication is the transmission of data between two points. A data communication system is a collection of hardware and software arranged to communicate information from one location to another.

Q.2 Define data, data transmission, analog signals and digital signals

Ans: Basic Terms of Data Communication:

The following terms are associated with data communication.

- Data
- Data transmission
- Analog signal
- Digital signal

Data:

Data means any types of raw facts and figures which can be provided as input to the computer for processing. Data can be in the form of text, sound, graphics, image or video.

Data transmission:

Data transmission means sending information from one place to other using computer networks and data communication systems. In computer technology, it means sending streams of bits or bytes from one place to another using copper wire, Fibre optics, satellite communication, etc.

Analog and Digital Signals:

A signal is a variation of physical quantity with time. The physical quantity can be temperature, pressure, rate of heart beat, etc. An electrical signal is a change in voltage or current with time.

Electrical signals can be divided into two main types, analog and digital signals.

Analog signals are continuous. They vary continuously within a range Analog transmission uses signals that are exactly the same as sound waves.

- Digital signals consist of binary digit 0 and 1 to represent information. These signals are transmitted by a series of "ON" and "OFF" signals by pulses of electricity or light The "ON" signal represents binary 1 and "OFF" signal binary 0.

Q.3 Define transmission media.

Ans: Transmission Media:

Transmission media provide the means by which data travels from source to destination. In other words, it is the pathway for transmitting data.

Q.4 Describe types of transmission media.

Ans: Types of Transmission Media:

There are two types of transmission media, Guided Media and Unguided Media

Guided Media:

Guided media uses cabling system that guides the data signals along a specific path. Different types of guided media are twisted pair, coaxial cable and Fibre optic cable.

Unguided Media:

Unguided media signals travel through open space and nothing guides them along any specific path.

Point To Ponder

Why do satellites stay in orbit and never fall on the earth?

Ans: This is the law of inertia. The force of gravity acts upon a high speed satellite to deviate its trajectory from a straight-line inertial path. Indeed, a satellite is accelerating towards the Earth due to the force of gravity. Finally, a satellite does fall towards the Earth; only it never falls into the Earth.

Q.5 Define amplification.

Ans: Amplification:

Amplification refers to strengthening of signal to solve the problem of attenuation in data transmission.

Amplifier:

An **amplifier** is a device used in data communication that receives weak signals, amplifies it and then retransmits.

Q.6 List the communication devices.

Ans: Communication Devices:

A communication device is hardware that is used for transmission of information from one place to another between computers and other devices.

The following communication devices are commonly used in computer networks in data communication systems.

- Dial-up Modem
- Network Interface Card
- Router
- Switch/Access Point

For Your Information

The first dial-up modem was built in 1962. It had a speed of 300 bits per second.

Do You Know?

Wireless network card provides an easy way to create a wireless network but it is slow and less reliable than wired network card.

Q.7 List the data transmission terminologies.

Ans: Communication Terminologies:

Communication Terminologies refers to terms or words that are related with data transmission or characteristics of communication channel.

Data Transmission Terminologies:

The following terms are used to determine the data transmission capabilities of a transmission media such as telephone line, coaxial cable, etc.

- Data rate
- Baud rate
- Bandwidth
- Signal to Noise Ratio

Q.8 Describe Signal-to-Noise Ratio.

Ans: Signal-to-Noise Ratio:

Signal-to-noise ratio is the ratio of signal power to the noise power that causes errors in data transmission. In other words, it means the ratio of useful data transmission to errors caused by noise over a transmission medium.

The measurement of Signal-to-noise ratio defines the data transmission quality of a communication medium.

If a transmission line has Signal-to-noise ratio higher than **1:1** that means more signal transmission than noise.

Q.9 Use appropriate formulae to determine the characteristics of a communication channel

OR

Describe the Characteristics of Communication Channel.

Ans: Characteristics of Communication Channel:

The maximum number of bits that can be transmitted over a communication line is a characteristic of transmission media. If more bits per second are transmitted than the line is capable of, some information will be lost due to transmission errors.

The baud rate can be calculated as:

$$\textit{Baud rate} = \textit{Number of signal changes per second}$$

The baud rate and data transmission rate measured as bits per seconds are not always the same.

For example, the Baud rate of a transmission line that uses modem is 28 kbps. If the electrical signal has two states to represent binary digits 0 and 1, then the Baud rate and data rate are the same.

If the electrical signal has four states to represent 00, 01, 10 and 11 as mentioned earlier, then Baud rate and data rate will not be the same.

Data rate will be calculated as:

$$\textit{Data rate} = 2 \times \textit{Baud rate} = 2 \times 28 = 56\ \textit{kbps}$$

KEY POINTS

- Data communication refers to transmission of information from one location to another using copper wires, Fibre optics, satellites, etc.
- A data communication system is a collection of hardware and software arranged to communicate information from one location to another.
- Analog signals are continuous. They vary continuously within a range. Analog transmission uses signals that are exactly the same as sound waves.
- Digital signals consist of binary digit 0 and 1 to represent information. These signals are transmitted by a series of "ON" and "OFF" signals by pulses of

electricity or light. The "ON" signal represents binary 1 and "OFF" signal binary 0.

- Transmission medium is the physical pathway over which message is transmitted from sender to receiver.
- Protocol is a set of rules between two communication devices that govern the process of data communication.
- In asynchronous transmission, time interval between each character is not the same. Each character is transmitted with additional start and stop bits.
- In synchronous transmission, time interval between each character is always the same. It does not require start or stop bits.
- Guided media uses cabling system that guides the data signals along a specific path.
- Unguided media signals travel through open space and nothing guides them along any specific path.
- Radio waves are electromagnetic waves that are propagated by antennas
- Satellite is an object that is placed in an orbit around the earth and revolves around it with speed that is same as the rotational speed of earth for communication.
- Attenuation is signal fall off with distance in guided or unguided media.
- Distortion refers to signal change in shape or form as it travels through communication lines.
- Cross talk refers to undesired signals that enter the path of the transmitted signal due to electromagnetic radiation.
- A Network Interface Card (NIC) is used to connect computers together to create computer network and make communication between computers possible.
- A router is a communication device used to connect computers together in different networks.
- A switch is used for connecting computers together in wired local area network whereas access point connects computers in wireless local area network.

EXERCISE

Q1. Select the best answer for the following MCQs.

i. In which type of data transmission start/stop bits are used?

A. Synchronous transmission B. Asynchronous transmission
C. Satellite transmission D. Microwave transmission

ii. In which of the following transmission, the time interval between the characters is always the same?

A. Synchronous transmission B. Asynchronous transmission
C. Satellite transmission D. Microwave transmission

iii. Which of the following transmission media uses light waves for transmitting information?

A. Coaxial cable B. Twisted pair cable

C. Telephone line D. Fibre optic cable

iv. Which of the following is used for short distance communication?

A. Radio signals B. Microwave
C. Infra-red D. Satellite communication

v. In which of the following impairment, the strength of signal falls off with distance?

A. Distortion B. Attenuation
C. Cross talk D. Noise

vi. Which of the following impairment refers to undesired signals that enter the path of the transmitted signal due to electromagnetic radiation?

A. Distortion B. Attenuation
C. Cross talk D. Noise

vii. Which of the following device is used for connecting computers together in wireless local area network?

A. Dial-up modem B. Router
C. Switch D. Access point

viii. Which of the following device is used for connecting computers together in wired local area network?

A. Dial-up modem B. Router
C. Switch D. Access point

ix. Which of the following device forwards information from one network to another by selecting the best pathway available?

A. Dial-up modem B. Router
C. Switch D. Access point

x. What represents the overall data transmission capacity of a computer network?

A. Data rate B. Bandwidth
C. Signal strength D. Baud rate

Answers

i. B	ii. A	iii. D	iv. C	v. B
vi. C	vii. D	viii. C	ix. B	x. B

Q2. Write short answers of the following questions.

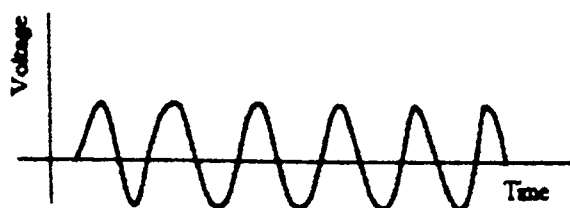
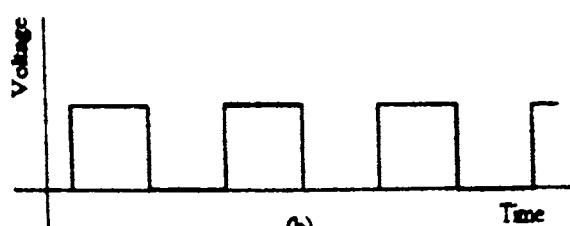
i. Differentiate between analog and digital signals.

Ans: Difference between analog and digital signals:

Analog signals:

Analog signal is in continuous form. It varies continuously within a range as shown in Fig (a). **For example**, sound is an analog signal. Analog transmission uses signals that are exactly the same as sound waves.

Digital signals:

Digital signals are not continuous. They switch between two discrete, low and high voltage levels as shown in Fig (b). In digital computers, low voltage level represents binary 0 and high voltage level represents binary 1. Information represented in digital form can be easily transmitted by series of "ON" and "OFF" signals by pulses of electricity. A pulse "ON" can represent 1 and the absence of pulse "OFF" can represent 0.

(a) Analog and (b) Digital Signals

OR (Second Answer)

Difference between analog and digital signals:

	Analog signal	Digital signal
Basic	An analog signal is a continuous wave that changes over a time period.	A digital signal is a discrete wave that carries information in binary form.
Representation	An analog signal is represented by a sine wave.	A digital signal is represented by square waves.
Description	An analog signal is described by the amplitude, period or frequency, and phase.	A digital signal is described by bit rate and bit intervals.
Range	Analog signal has no fixed range.	Digital signal has a finite range i.e. between 0 and 1.
Distortion	An analog signal is more prone to distortion.	A digital signal is less prone to distortion.
Transmit	An analog signal transmit data in the form of a wave.	A digital signal carries data in the binary form i.e. 0 and 1.
Example	The human voice is the best example of an analog signal.	Signals used for transmission in a computer are the digital signal.

ii. Why digital signals are used in computer systems?

Ans: Information represented in digital form can be easily transmitted by series of "ON" and "OFF" signals by pulses of electricity. A pulse "ON" can represent 1 and the absence of pulse "OFF" can represent 0.

Multiple bit (0,1) streams are used in a computer network. Digital data can be compressed relatively easily, thereby increasing the efficiency of transmission.

That is why digital signals are used in computer systems.

iii. Name the properties of a good communication system.

Ans: Characteristics of a Good Communication System:

Following are the properties of a good communication system.

Delivery:

Data communication system must deliver the message to the correct destination. Message must be received by only the device or user to whom it is sent.

For example, when e-mail is sent to a person, it is received only by the person to whom it is addressed. This is managed by the protocol used in the data communication system.

Accuracy:

System must deliver the message accurately without any change. If incorrect data is transmitted by the system, it may not be usable by the receiver.

For example, when data is transmitted over a long distance, it may get corrupted due to transmission errors. The data that is not correctly received at the destination is retransmitted from the source. This is ensured by the protocol used in the data communication system.

Timeliness:

The system must deliver the data without significant delay in a timely manner. It is very important in real time transmission such as video conferencing that video and audio are delivered as soon as they are produced. Data delivered late may be useless.

Some real time systems require immediate transmission of data within limited time.

For example, a computerized real time system is used to monitor the temperature in an oil refinery. If the temperature is getting too high, it must be transmitted immediately otherwise there can be an explosion.

iv. Give any three reasons why guided communication medium is more reliable than unguided medium.

Ans: The purpose of Guided media is to reduce cross talk and electromagnetic interference and make the transmission more reliable.

It provides high quality transmission at extremely fast speed. It can transmit trillions of bits per second.

Guided media is not affected by electromagnetic fields and can transmit both analog and digital signals.

Guided media is used for data transmission over long distance.

Unguided Media has multipath interference, due to reflections from land, water, natural and human-made objects.

That is why guided communication medium is more reliable than unguided medium.

v. What is meant by transmission impairment?

Ans: Transmission Impairments:

The errors that occur during data communication from one point to another are called transmission impairments.

When a signal is transmitted over a communication medium, it may have different types of impairments. Impairments occur due to imperfect characteristics of communication medium. As a consequence, the received and the transmitted signals are not always the same.

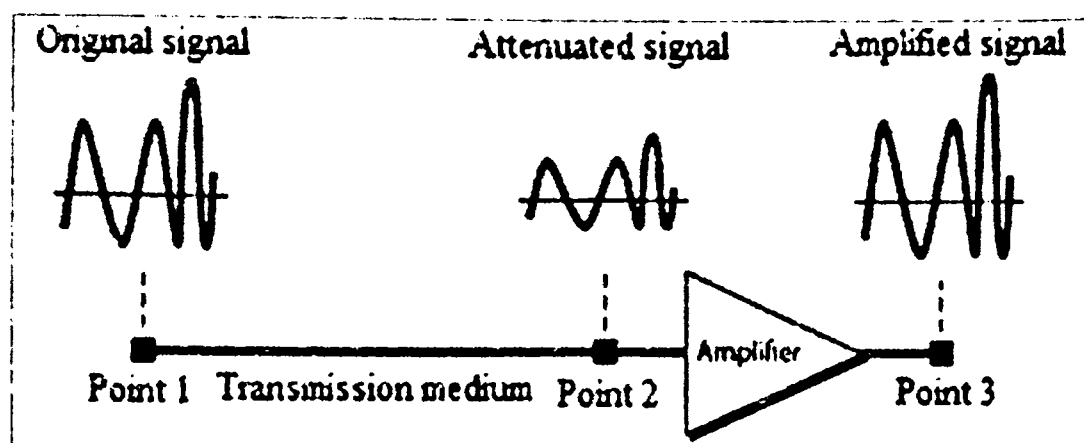
Types of impairments:

The types of impairments in communication media are:

i. Attenuation
ii. Amplification
iii. Distortion
iv. Cross talk

vi. Differentiate between attenuation and distortion.

Ans: Attenuation:

Attenuation is the fall of signal strength with the distance as signal travels through the communication media. If the attenuation is too much, the receiver may not be able to detect the signal at all.

Attenuation in data communication

Distortion:

Distortion refers to change in shape or frequency of digital signal when it is transmitted over a communication line. Fig (a), shows the transmitted signal and Fig (b), shows the distorted received signal.

Communication line delays the signal frequency by different amounts because different frequency components travel at different speed. Therefore, various frequency components of a signal are received at different delays. This causes distortion in digital signals.

Distortion in digital signal

vii. What is cross talk?

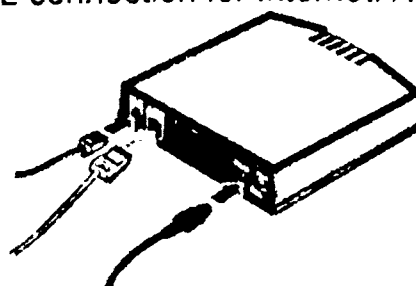
Ans: Cross Talk:

Cross talk occurs in guided media. As signal is transmitted through a wire, undesired signals enter the path of the transmitted signal due to electromagnetic radiation. It is caused because of putting several wires together in a single cable.

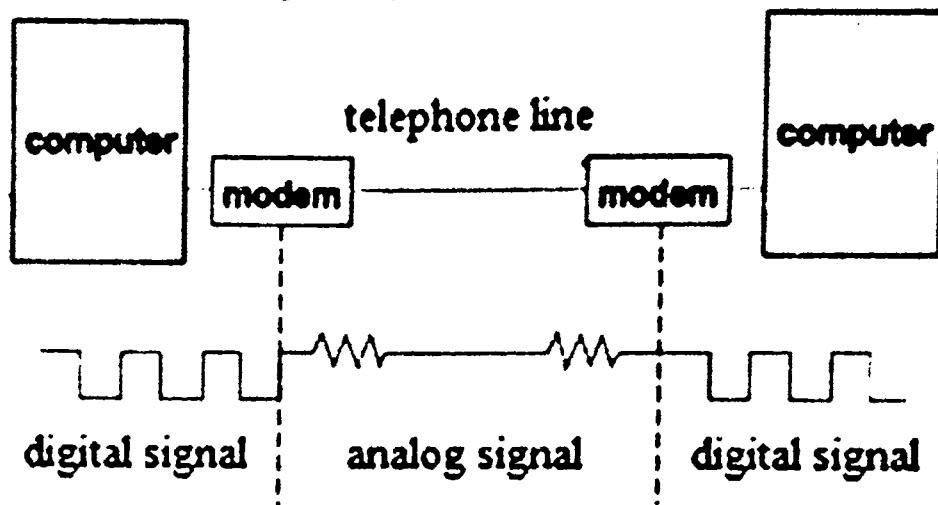
Sometimes, user can hear another conversion in the background when talking on the phone. This happens by the coupling between two wires that are close to each other.

viii. What is Dial-up modem? Why is it used?

Ans: Dial-up Modem:

Dial-up modem provides Internet connection through telephone line. Maximum speed of Dial-up modem is 56 Kilobits per second which is very slow. It is being replaced by faster DSL connection for Internet. A Dial-up modem is shown in Fig.

Dial – up modem

Uses of Dial-up Modem:

A telephone line is used for voice transmission which is analog signal. A modem converts digital computer signal to analog form for transmission over telephone line as shown in Fig. This process is called modulation.

Transmission of data using modem

Another, modem at the receiving end, converts the analog signal back to digital form which is called demodulation.

Modem is abbreviation of ***Modulator-Demodulator***.

ix. Define data rate and baud rate.

Ans: Data Rate:

Data rate is the speed with which data can be transmitted from one device to another. It is generally measured in Kilobits (thousand bits) or Megabits (million bits) per second.

Note: The abbreviation kbps, is used for kilobits per second and mbps for million bits per second.

Baud Rate:

Baud is the rate of change of electrical signals per second during data communications. An electrical signal can have two or more than two states to represent binary digits 0 and 1.

If an electrical signal has two states to represent binary digits then one state represents binary 0 and the other binary 1. In this case the baud rate and the number of bits transferred per second (data rate) are the same.

If an electrical signal has four states then each state can represent two binary digits.

For example, the analog signals generated by modem can have four voltage levels such as 1, 2, 3 and 4 Volts. There are four states of analog signal one for each voltage level. These four voltage levels can be used to represent 00, 01, 10 and 11. These will double the bit transfer rate.

x. Define bandwidth.

Ans: Bandwidth:

Bandwidth describes the overall data transmission capacity of a medium or channel. It represents the amount of data that passes through a network connection per unit of time.

Bandwidth is also measured in bits per second like data rate.

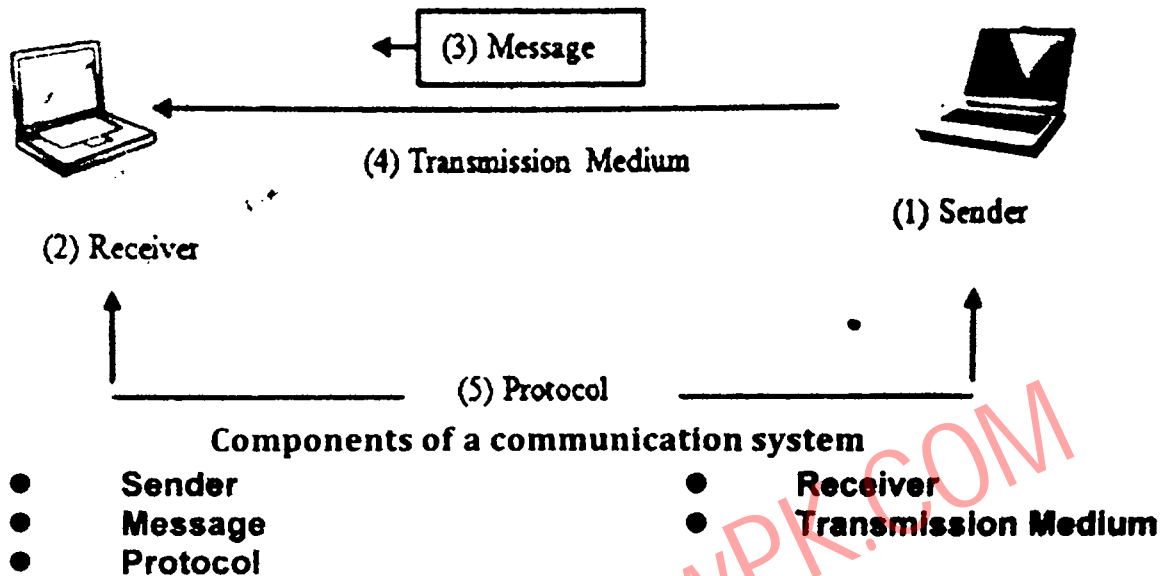
Q3. Write long answers of the following questions.

i. Describe the components of communication system with the help of diagram.

Ans: Components of a Communication System:

Communication system consists of the following five basic components as shown in Fig.

Components of a communication system

- **Sender**
- **Receiver**
- **Message**
- **Transmission Medium**
- **Protocol**

Sender:

It is the device which sends the message. In other words, it is the source of message that can be a computer, telephone handset, etc.

Receiver:

It is the device which receives the message. In other words it is the destination of message that can be a computer, radio, telephone handset, etc.

Message:

It is the data to be transmitted. It can be text, graphics, image, sound or video.

Transmission Medium:

It is the physical pathway (also known as channel) over which the message is sent from sender to receiver. Some examples of transmission media are coaxial cable, Fibre optic cable, microwaves, etc.

Protocol:

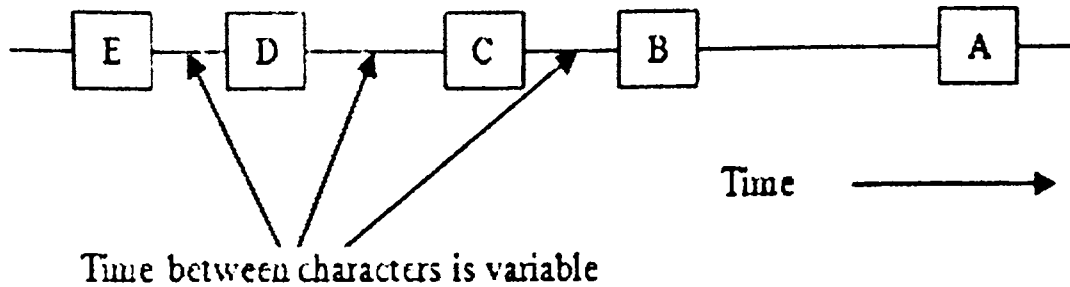
It is the set of rules between the two communicating devices that governs the process of data communication. Without a protocol, two devices may be connected but they cannot communicate with each other.

ii. Explain asynchronous and synchronous transmission modes with examples.

Ans: Asynchronous and Synchronous Transmission modes:

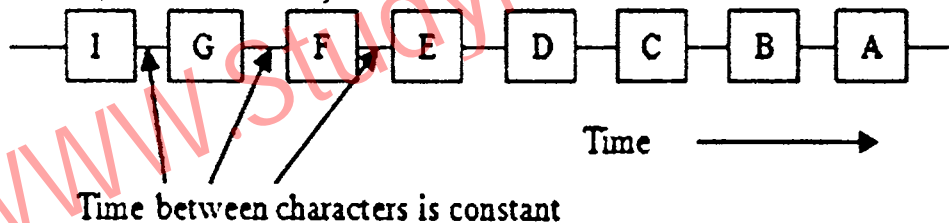
Asynchronous and synchronous transmissions are the methods by which characters are transferred between components within the computer or between the computer and an external network.

Asynchronous Transmission:

The transmission mode in which time interval between each character is not the same is known as asynchronous transmission. This is shown in Fig.

Asynchronous transmission

- In asynchronous transmission, each character is transmitted with additional control information. Control information consists of additional start and stop bits. Start bit indicates that transmission is about to start and stop bit indicates that it is about to stop.
- Start bit is generally 0 and stop bit is 1.
- Between the start and stop bits, the bits representing a character are transmitted at uniform time intervals.
- Asynchronous transmission is slow because of the additional bits transmitted with each character. It is suitable for low speed connection between system unit and keyboard or mouse.

Synchronous Transmission:

The transmission mode, in which time interval between the characters is always the same, is known as synchronous transmission. This is shown in Fig.

Synchronous transmission

- In synchronous transmission, there is no control information added with the characters.
- Data consisting of 0s and 1s is transmitted as one long stream of bits. The receiver counts the bits as they arrive and recognizes the characters.
- Synchronous transmission is faster than asynchronous transmission because it does not require extra start and stop bits. Therefore, it is used for fast data communication between computers in computer networks.

iii. Describe the following guided media.

a) Twisted pair cable

b) Coaxial cable

c) Fiber optic cable

Ans: a) Twisted pair cable:

Twisted pair cable is the most commonly used cable for data communication. It consists of pairs of copper wires twisted around one another as shown in Fig.

Twisted pair cable

Purpose of twisting the cables:

The purpose of twisting the cables is to reduce cross talk and electromagnetic interference and make the transmission more reliable.

Telephone cable consists of two twisted insulated wires.

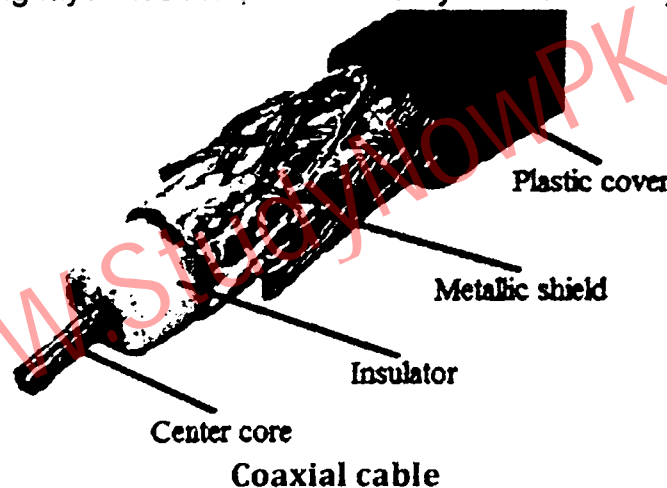
Computer network cable consists of 4 pairs of twisted cables.

Transmission speed of twisted pair cable:

Transmission speed of twisted pair cable ranges from 2 million bits per second to 10 billion bits per second.

b) Coaxial cable:

Coaxial cable is used for local area networks and cable television systems. It consists of copper wire surrounded by insulating layer.

The insulating layer itself is surrounded by conductive layer as shown in Fig.

Coaxial cable

Purpose of Insulation:

Insulation reduces interference and distortion.

Transmission speed Coaxial Cable:

Transmission speed ranges from 200 million bits per second to more than 500 million bits per second.

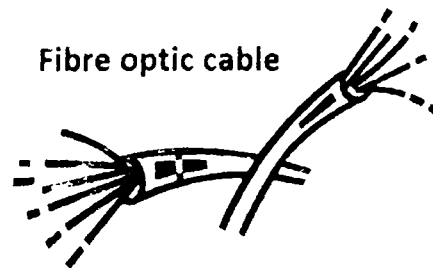
c) Fiber optic cable:

Fibre optic cable consists of smooth hair-thin strands of transparent material. In Fibre optic communication, the transmitter has a converter that converts electrical signals into light waves. These light waves are transmitted over the Fibre optic cable. Another converter is placed at the receiving end that converts the light waves back to electrical signals.

Capacity of single Fibre optic cable:

A single Fibre optic cable can carry up to 50,000 communication lines. It provides high quality transmission at extremely fast speed. It can transmit trillions of bits per second.

It is not affected by electromagnetic fields and can transmit both analog and digital signals.

Note: Fiber optic cable is more expensive than twisted pair and coaxial cables. It is used for data transmission over long distance. Fibre optic cable is shown in Fig.

iv. Describe any three types of unguided media.

Ans: Unguided Media:

Unguided media signals travel through open space and nothing guides them along any specific path. They do not use cables for data transmission.

Types of unguided media:

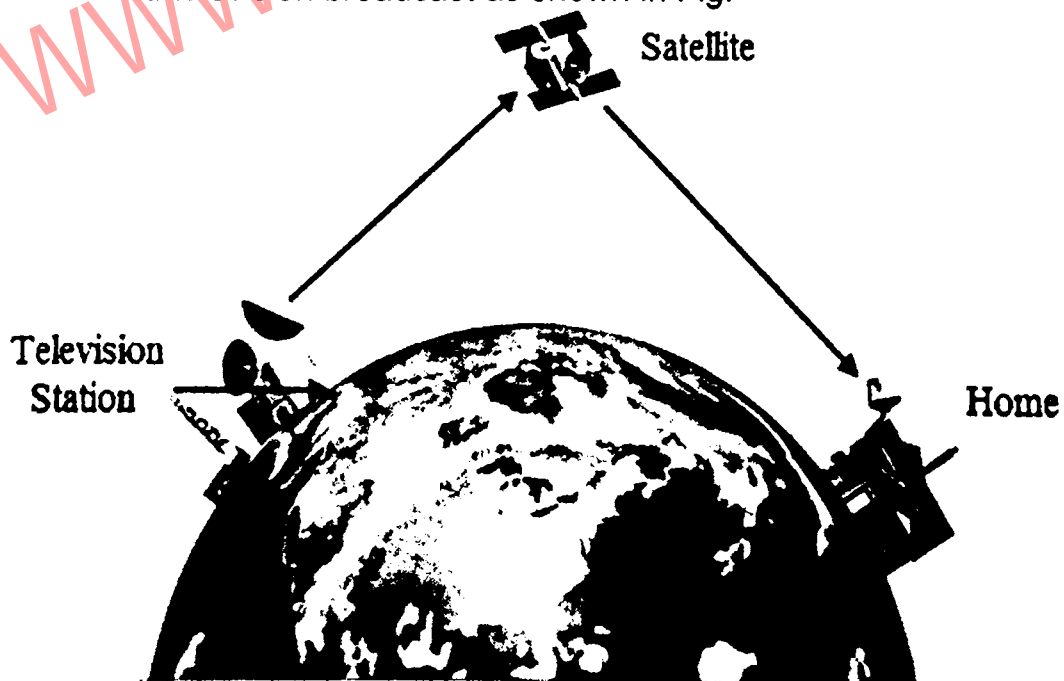
Unguided media can be classified into radio waves, microwave, infra-red and satellite communication.

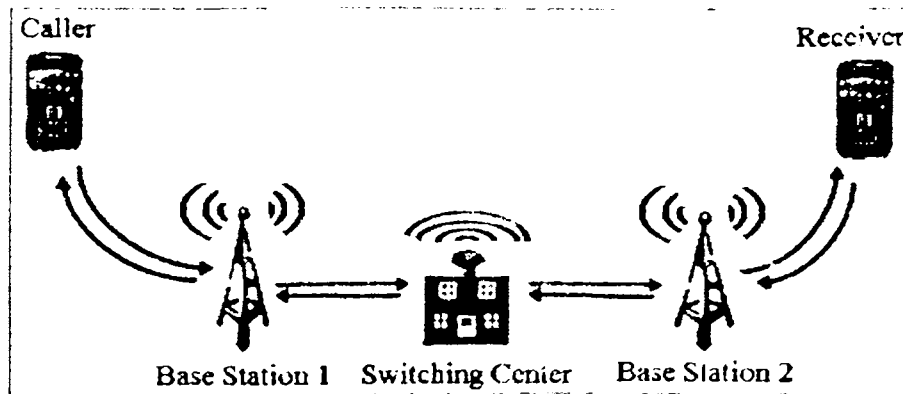
Radio Waves:

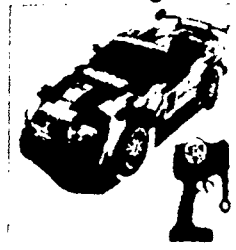
Radio waves are electromagnetic waves that are propagated by antennas. Radio transmission consists of a transmitter and a receiver.

A transmitter transmits a radio signal to a receiver which receives it. Radio waves are used to transmit music, conversation, pictures and data. Data can be transmitted over long distance using radio waves. These waves are invisible and undetectable to human beings.

The following are some applications of radio waves.

- Radio and television broadcast as shown in Fig.

Television broadcast

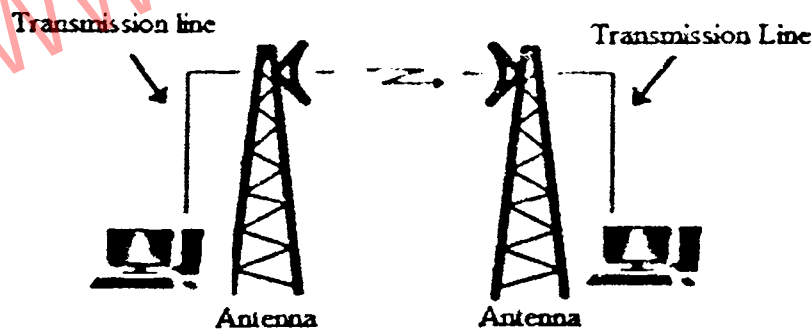
- Cell phones communication as shown in Fig.

Cell phone communication

- Radio-controlled toys as shown in Fig.

Radio controlled car

- Satellite communication
- Wireless networks and wireless Internet

Microwave:

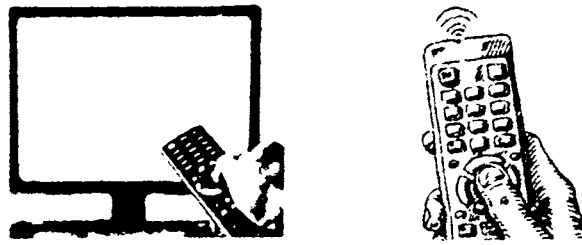
Microwave signals travel through open space like radio waves. Microwaves provide much faster transmission rate than telephone lines or coaxial cables.

Microwave antennas are installed on high buildings or high towers as shown in Fig. The transmitting and the receiving sites must be within sight of one another. Microwaves are used for satellite communication and other long distance wireless communications.

Microwave Transmission

Infra-red:

Infra-red waves are light energy that we cannot see. It travels through space at the speed of light. It is used for short distance communication.

Infra-red waves are usually used in remote controls for television, DVD players and other similar devices. Infra-red wireless signals are disrupted by persons or objects in between the transmitter and receiver but it does not get interference of other radio signals.

It is also used in industrial, scientific and medical appliances and night-vision devices. Infra-red communication between television and remote control is shown in Fig.

Infra – red communication

Bluetooth:

Bluetooth is a wireless communication technology that uses radio waves to connect portable electronic devices over short distance. It eliminates the need for cable connection and provides fast and reliable transmission.

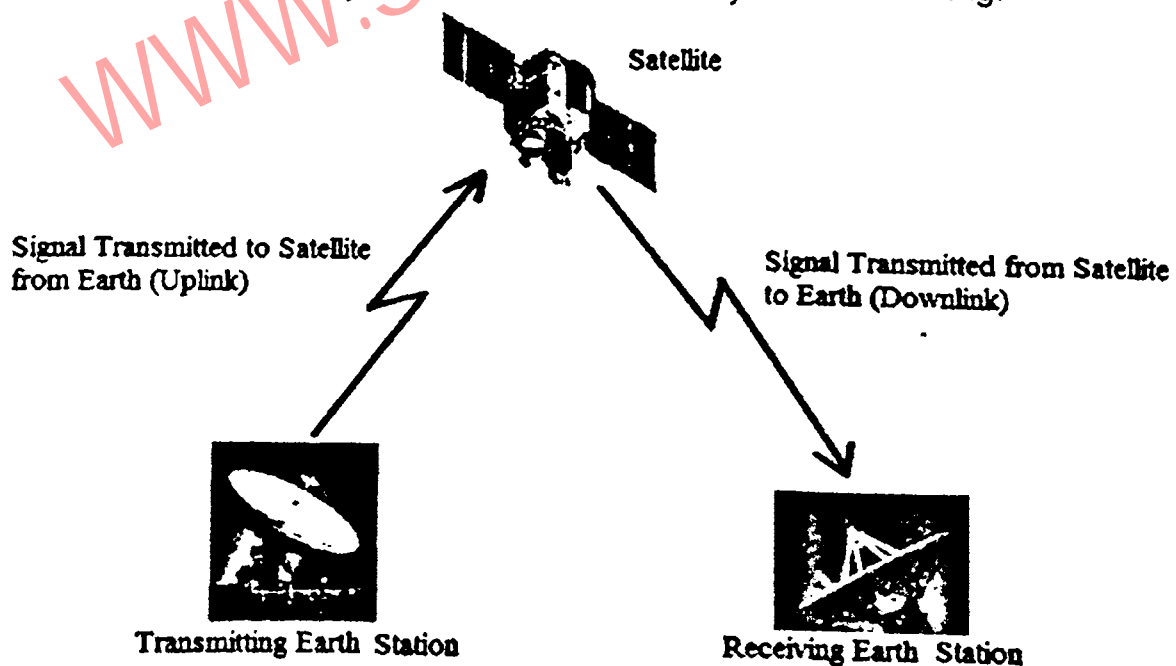
It supports networking of wide range of portable devices that work on low battery. These devices include mobile phone, mouse, keyboard, wireless speaker, wireless headset, tablet, laptop computer and personal computer.

Laptop computer has built-in Bluetooth but personal computer can use Bluetooth adapter to communicate with Bluetooth devices.

The most common use of Bluetooth is connecting a mobile phone to a wireless headset or to a laptop computer to transfer voice data. Bluetooth technology can transmit text, image, voice and video.

Satellite:

A satellite is an object that is placed in an orbit around the earth and revolves around it with speed that is slightly faster than Earth's average orbital speed for communication.

It is a wireless Receiver and Transmitter used for transmitting data over long distance at high speed. Ground stations beam signals through antennas to satellites. Satellites amplify and retransmit the signals to another ground station which can be located many thousands of miles away as shown in Fig.

Satellite Communication

Drawback of satellite communication:

The main drawback of satellite communication is the high cost of placing the satellite into its orbit. Satellites are launched by rockets or space shuttles and precisely positioned in the space with an orbit speed that exactly matches with the rotation speed of the earth.

v. Describe the functions of the following communication devices.

a) Router

b) Network Interface Card (NIC)

c) Switch/Access point

Ans: a) Router:

Router is a communication device that is used when two networks have to be connected for communication. They send information from one network to another by selecting the best pathway available.

Types of routers:

There are two types of routers i.e. wired and wireless.

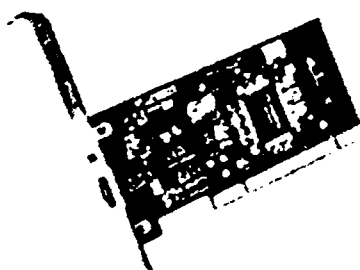
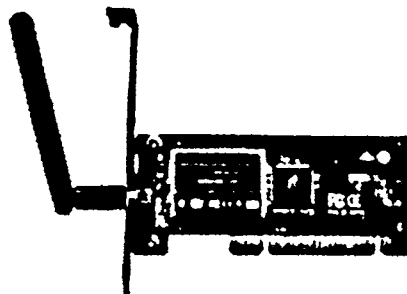
A wireless router is shown in Fig. This router is used to connect wireless devices such as laptop computer and mobile phone to Internet.

b) Network Interface Card (NIC):

A Network Interface Card (NIC) or simply network card is used to connect computers together to create computer network. It makes communication between computers possible.

It is a card that is installed on the motherboard. In modern computers, it is integrated on the motherboard.

Types of network cards:

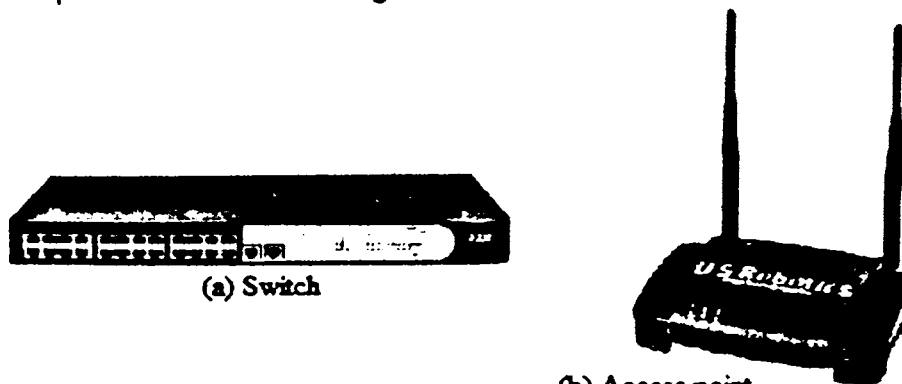
There are two types of network cards, wired network card and wireless network card. Wired and wireless network cards are shown in Fig.

(a) Wired Network Card (b) Wireless Network Card

Network cards

c) Switch/Access Point:

A switch/access point is used for connecting computers together in local area network (LAN). Switch is used in wired networks whereas access point is used in wireless networks.

A switch/access point receives information from a computer in the network, inspects it and then transmits it appropriately to the destination computer. A switch and an access point are shown in Fig.

(a) Switch

(b) Access point

Switch and access point

Lab Activities

Activity 1:

Students should be shown twisted pair, coaxial and fibre optic cables and their usage in data communication.

Activity 2:

Students should be shown communication devices such as network card, router, switch, etc.